Creating a Knowledge Base for Management of Southern Bottomland Hardwood Ecosystems

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Abstract

We describe an interdisciplinary approach to forecasting potential impacts of even-aged and uneven-aged silvicultural treatments upon bottomland hardwood ecosystems in the Southern United States. Our approach involves identifying scientists with expertise in key disciplines; utilizing the Delphi technique to develop consensus among these scientists on important system processes and functions, and to estimate mean values for management effects on same; and synthesizing results in conceptual models of key ecological, physical, and social relationships. These models will provide conceptual support for long term field research on management of these ecosystems underway at four sites in the South.

Key words: Ecosystem management, adaptive management, bottomland hardwoods, Delphi, silviculture.

Introduction

Two-thirds of the annual losses of wetlands in the conterminous United States occur in forested wetlands, primarily in the South (Wilen and Frayer 1990). There are almost 31 million acres of forested wetlands in the South, comprising less than one-third of the forested wetlands occurring prior to European settlement. While the loss of wetlands continues, the rate of loss has slowed. Nevertheless, only 5 million acres of forested wetlands remain of an estimated 21 to 23 million acres in the Mississippi River floodplain (Turner and others 1981; The Nature Conservancy 1992), and the loss of forested wetlands in other parts of the South is just as striking (Tansey and Cost, 1990). Most of the forested wetlands in the South occur in the floodplains of rivers within a broad coastal plain stretching from Texas to Virginia.

In 1991, the National Research Council (NRC) called for an active and ambitious restoration program which offsets further wetland losses and contributes to an overall increase of 10 million acres by the year 2010 (NRC 1991). A first step in any restoration effort is to identify the key functions of undisturbed wetland sites. These reference sites must be identified and monitored in order to develop criteria for measuring the "success" of restoration projects.

Although we have a conceptual understanding of these wetland ecosystems, our present knowledge is fragmented and lacks sufficient detail for managing them on an ecosystem basis. Our lack of knowledge also makes it difficult to monitor forest health or to restore degraded wetlands. While we are increasingly aware of how important these wetlands are, and of their dramatic rate of disappearance, we have little scientific information that quantitatively describes their important biological, chemical, and physical functions. Mitigation and restoration efforts, and the development of sustainable silvicultural techniques are stymied by this lack of knowledge.

To improve our ability to manage and restore bottomland hardwood forest ecosystems, which are one component of the forested wetlands in the South, an interdisciplinary team of researchers from several Federal agencies and universities (Interagency Forested Wetlands Initiative) are cooperating in an integrated regional study of the structure and function of bottomland hardwood forests in river bottoms in the Atlantic and Gulf Coastal Plains. This wetland type was singled out for study because it makes up over half (16 million acres) of the remaining southern forested wetlands, is a significant forest resource (McWilliams and Faulkner 1991) that adds considerably to regional landscape diversity, and provides habitat for plants and wildlife (Wharton and others 1981), particularly sensitive neotropical migratory birds and other fauna.

Objectives

The overall objective of the Bottomland Hardwood Ecosystem Management Project (the Forest Service portion of the Interagency Forested Wetlands Initiative) is to obtain a quantitative understanding of the structure and functions of bottomland hardwood ecosystems (Harms and Stanturf 1994). Specifically, the objectives are (1) to quantify their physical, chemical and biological functions, and (2) to document and evaluate the effects of silvicultural manipulation on key functional capacities. The project is being conducted in two phases: Phase I, now underway, addresses the first objective by selecting four representative systems and measuring functions over a 4-year calibration

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period. During Phase II, silvicultural treatments will be imposed to directly examine the effects of stand manipulation on wetland functions and ecological processes.

Because of our fragmented and incomplete understanding of these ecosystems, we could not define at the outset the specific silvicultural treatments that would appropriately compare even-aged versus uneven-aged management, nor did we have an adequate understanding of the key ecological processes that needed to be monitored in order to evaluate the effects of manipulation. Given this uncertainty, we undertook an adaptive management approach to develop the knowledge base needed to assess alternative management strategies. This paper describes our efforts to define cause and effect relationships among natural processes operating in bottomland hardwood ecosystems and describes how management activities directly and indirectly affect natural processes at multiple scales in these dynamic systems. A second goal of this adaptive management component is to develop a consensus among bottomland hardwood experts on all factors that should be evaluated in comparing the two management systems.

Methodology

We have chosen the Delphi method as a means to rapidly accumulate existing expertise on the structure, functions, and management of bottomland hardwood ecosystems. The Delphi technique is a form of structured communication between knowledgeable individuals designed to capture and distill their collective expertise in order to apply it to solving complex problems (Linstone and Turoff 1975). It was initially developed by RAND Corporation in the early 1950's in order to evaluate a national security issue, specifically, the question "How many A-bombs of the type that destroyed Hiroshima would it take to cut the US gross national product by 75 percent?" (Moore 1987). Because of the initial intention to use this as a forecasting tool, the technique was named for the Oracles at Delphi, Greece, who could predict future events (Moore 1987).

The first nonmilitary application of the Delphi technique, published in 1963 by Olaf Helmer and E. S. Quade (1963), suggested using the technique for predicting and planning development economics. The first large-scale Delphi study was the "Report of a Long-Range Forecasting Study" by T.J. Gordon and Olaf Helmer, published by RAND in 1964. This study was used to forecast potential scientific and technological events over a 10 to 50 year span. These two studies extended awareness of the Delphi method beyond the defense community (Linstone and Turoff 1975).

Since that time, researchers in a variety of disciplines have used Delphi applications. In the field of education it has been used to develop course syllabi and develop innovative teaching techniques (Alabama Dept. of Education 1974). Delphi has been used in planning, allocation of research and development resources, forecasting trends, community planning, and political policy development (Eschenbach and Geistauts 1986); and as an evaluation tool for such social problems as drug abuse, child abuse, and violent crime (Holeman 1978, Stephens and Tafoya 1985). The method is useful for risk assessment and economic, environmental, and social impact assessment (Robinson 1991, Clouser 1986). It is becoming widely used for marketing research (Dull 1988).

Within the natural resources field, the method has been used to develop basic information and prediction models for resolution of resource problems in the Great Lakes area (Ludlow 1975); to develop habitat suitability index curves for wildlife (Crance 1987); in recreation planning on USDA Forest Service lands (Schneider and others 1993); to evaluate elk habitat quality (Schuster and others 1985); and to evaluate stewardship attitudes and activities on private forest land (Egan and others 1993).

What is Delphi?

Essentially, Delphi consists of a series of questionnaires administered to knowledgeable individuals, and designed to build and refine a body of consensual knowledge on a topic of interest (fig. 1). The initial questionnaire elicits a general assessment of the topic which is refined in subsequent

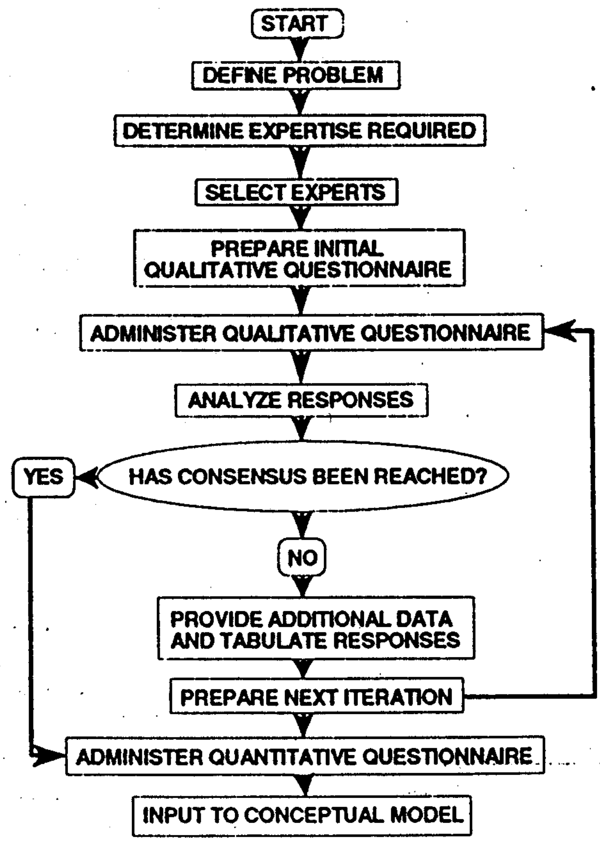

Figure 1–Flow chart, Delphi application (after Tersine and Riggs 1976).

questionnaires. Each iteration seeks to clarify areas of agreement and disagreement, and the process continues until a satisfactory group consensus is reached. Throughout these questionnaires, participants discuss issues, document or justify their assessments, and are given an opportunity to reassess earlier positions in light of feedback from other participants.

The Delphi technique resembles the nominal group technique, but does not require a face-to-face meeting (Delbecq and others 1975). The anonymity of survey panel members and their responses is thus preserved, thereby preventing any one member of the panel from unduly influencing the responses of other panel members (Lindeman 1975). Multiple iterations, statistical analysis of panel responses, and controlled feedback of responses to panel members further differentiate Delphi from other techniques. Panel members communicate with each other in a limited, goal-centered manner through statistical summaries and a minority report (Lindeman 1975).

Strauss and Zeigler (1975) differentiate several types of Delphi by research goals. The *numeric* Delphi is used to specify a single or a minimum range of numeric estimates or forecasts, for example, the size of the world population in the year 2005. The *policy* Delphi defines a range of answers or alternatives to a current or anticipated problem, such as acceptable silvicultural practices on USDA Forest Service land. The *historic* Delphi has been infrequently used to explore issues that fostered a specific decision or policy in the past (Strauss and Zeigler 1975). Delbecq and others (1975) note that Delphi is a decision-making tool which is easily "modified to respond to the needs of the individual decision-makers."

Among the attributes of the Delphi method is that it maintains attention directly on the selected issue and avoids the sidetracking which may occur in group meetings. Delphi provides a framework within which individuals from diverse backgrounds or remote locations can work together on the same problem. The records concerning the study can be precisely documented, as all the responses are written (Enzer and others 1971). Because anonymity of the participants is a key factor of a Delphi study, three typical problems encountered in group meetings are avoided: (1) participants are less subject to the *halo effect*, where the opinion of one highly respected participant influences the opinions of others strictly on the basis of that respect, (2) participants are also less subject to the *bandwagon effect* which encourages agreement with the majority (Tersine and Riggs 1975), and (3) a situation is in place that encourages a *consensus* rather than *majority rule* (minority opinion is given and considered).

Delphi was developed as a tool to decrease the uncertainty regarding events and processes, not to eliminate it. The predictions and estimations made even in a *numerical* Delphi are *subjective*, based on the opinions and knowledge of the participants. Delphi results are the collective educated guess of knowledgeable persons.

Using Delphi in Ecosystem Management Research

Delphi appears to be well suited as a preliminary step in long-term ecosystem management research such as ours. Our understanding of the structure and functions of bottomland hardwood forests is fragmented and far from complete. While considerable expertise on various components of these systems exists, it is largely disciplinary, local, and has yet to be systematically integrated. Understanding of impacts of alternative silvicultural practices on these systems is similarly limited. Through the use of Delphi we hope to collect existing expertise and apply it to our study objectives.

Participant Selection

A Study Team of university and Forest Service researchers was formed in 1994 to instigate this research. A regional conference on bottomland hardwood forests held in Stoneville, MS served to identify both the key topics in managing this resource and the scientists currently working in the field (Stanturf 1994). Starting with the presenters at the Stoneville conference, Study Team members began to identify potential candidates for the Delphi panel.

Panelists will be individuals with widely recognized expertise in one of the following four areas relating to Bottomland Hardwood Ecosystems (BLHE):

(1) silviculture/ecology
(2) wildlife/biodiversity
(3) hydrology/soils
(4) management/social aspects/economics

These experts will be identified through networking, a sociological method designed to elucidate community power structure (Domhoff 1978). The Study Team will use their knowledge to construct an initial list of experts, striving to obtain as broad a range of expertise and professional affiliation as possible. Potential panelists will receive a letter explaining the study and requesting names of additional experts. From these responses the team will contact a second round of potential panelists consisting of any newly identified experts. This process will be repeated until no new experts are identified. The team will then contact all identified experts to invite them to participate in the Delphi study. We envision using a combination of mail, email, and FAX communications to administer the questionnaires.

Qualitative Delphi

While the data instrument in Delphi is called a questionnaire, it does not resemble a typical survey research questionnaire. The initial questionnaire might consist of an open-ended question. For example, we might ask, "What factors should be considered in evaluating even-aged versus uneven-aged management of bottomland hardwood ecosystems?" Another alternative would be to ask the experts to list the attributes or criteria they would use to compare even-aged versus uneven-aged management in terms of commodity and noncommodity values.

Alternatively, they could be given a list of attributes and asked for their additions, deletions, or organizational modifications. Responses to the initial questionnaire will be collected and summarized by the Study Team. These summaries will be used to construct the next iteration of the questionnaire. This second iteration will be used to clarify ideas brought out in the initial questionnaire. This process of controlled feedback and iteration will continue until a satisfactory degree of consensus among panelists is achieved on key questions. This collective consensus will contribute to development of a conceptual model of cause-and-effect relationships for natural processes.

Quantitative Delphi

A second phase of the Delphi study will be conducted to predict mean values for effects of management actions on important processes or functions. Experts will be asked to first identify the most important processes or functions that are affected by management. This will be done using a Likert scale from most affected to least affected. Panelists will be asked to justify all "high-impact potential" ratings and to suggest measures by which effects can be evaluated. Controlled feedback and iteration will again be used to obtain convergence on ratings and measures.

During this phase of the study, site-specific attributes of bottomland hardwood ecosystems will become important for obtaining consensus. This is because of the variety of possible interpretations of such ecosystems. For example, regeneration success following even-aged treatments will be judged differently if one expert pictures a cypress tupelo swamp while another pictures a red oak-sweetgum stand in an occasionally flooded second terrace. Case studies will be used to alleviate this problem. These case studies will reflect the actual Interagency Wetlands Initiative study sites in terms of such factors as hydroperiod, community composition and structure, and landscape. Panelists will be directed to base their evaluations on these site types whenever a general "wetlands" response is not appropriate.

Synthesis

~~The synthesis stage~~ of the Delphi effort will be instrumental in developing a biologically based computer simulation model of ecosystem behavior that can be used to analyze the response of bottomland hardwood ecosystems to disturbance. The overall Ecosystem Management project will provide three kinds of information necessary to develop the simulation model. First, process-oriented research will quantify plant-environment relationships. Second, research on ecosystem structure and function will provide the framework and sideboards necessary for the model. Third, response-to-disturbance research in phase 2 of the study will allow us to quantify the effects of disturbance or management activities on important wetland functions.

Because the information needed to develop this detailed quantitative model is lacking, the Delphi study is developing a conceptual model during the initial qualitative phase and parameterization will occur during the subsequent quantitative phase. A first draft conceptual model, produced using STELLA II, is shown in figure 2 (High Performance Systems, Inc. 1994). In this model, the rectangles represent stocks, things which accumulate and/or are depleted. The open arrows represent a flow into or out of a stock, and the circles represent converters, receptacles for specifying the logic that will regulate the volume of the flow. Figure 2 illustrates the general relationships between hydrologic, edaphic, and biologic factors. Ultimately, we hope to incorporate potentially significant social relationships within the model, including, for example, aesthetic, economic, and recreational values.

In the Qualitative Delphi phase, we will expand and refine this model. During the quantitative phase the stocks and flows in the model will be quantified using information available in the literature, provided by experts, or estimated during the field component of the Ecosystem Management study. The outcome of this model will help define cause and effect relationships between natural processes operating in bottomland hardwood ecosystems and will also be used to estimate how different management activities directly and indirectly influence natural processes. Tree vegetation is the primary target of most management activities in these systems. It is also a major biological component of the

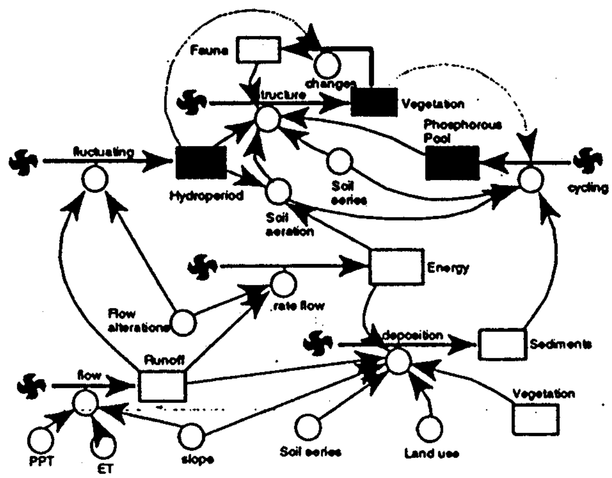

Figure 2–Diagram of forested wetland ecosystem simulation model produced using STELLA II. (High Performance Systems, Inc. 1994).

ecosystem, influencing in one way or another most aspects of ecosystem structure and function. The ability to predict the functional response of forested wetlands to different harvesting methods is central to developing useful guidelines for management. Several harvesting scenarios will be contrasted in the synthesis stage of the Delphi study and outcomes will be used in identification of the best harvesting techniques to be used as treatments in the field experiment (phase 2) planned for the Ecosystem Management study.

Summary

Bottomland hardwood ecosystems are complex and incompletely understood. Their significance as sources of ecological, social, and economic goods and services has increased as their areal extent has declined. Our over-arching objective is to advance understanding of how these systems work and how they may be sustainably managed to produce these goods and services. Collecting and synthesizing existing knowledge on bottomland hardwood ecosystems and their management is a first step toward this objective.

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